REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
30-09-2011	FINAL	01-04-2008 - 30-09-2011

4. TITLE AND SUBTITLE
EWALL: ELECTRONIC CARD WALL: COMPUTATIONAL SUPPORT FOR COLLABORATIVE DECISION-MAKING

5a. CONTRACT NUMBER

5b. GRANT NUMBER
N00014-08-1-0219

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
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5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
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8. PERFORMING ORGANIZATION REPORT NUMBER

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ARLINGTON, VA 22203-1995

10. SPONSOR/MONITOR'S ACRONYM(S)
ONR

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Unclassified, Unlimited, Copyright 2011 MIT/ONR

13. SUPPLEMENTARY NOTES

14. ABSTRACT
This effort is aimed at exploring computational opportunities for utilizing theories of team-collaboration. We introduce a first Framework for monitoring, assessing and measuring team-collaborative processes. The Framework helps explain team-collaborative processes as combinations of multiple Methods that can be studied individually or in combination. We also introduce a second Framework for describing, analyzing and developing team-collaborative scenarios, experiments and use-cases. The second Framework is designed to evaluate and study Methods in particular situations. Furthermore, we demonstrate opportunities for translating Methods into computational agents that can analyze and support team collaboration and knowledge management. A hypothetical scenario is used to demonstrate and explain the use of Methods and the conceptualization of computational agents.

15. SUBJECT TERMS
Collaboration, Knowledge Management, Distributed Cognition, Team Mental Model, Sense-Making, Computational Agents, EWall

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON / 19b. TELEPHONE NUMBER *(Include area code)*
U	U	U	UU	15	PAUL KEEL / 617 249 0730

EWALL: ELECTRONIC CARD WALL: COMPUTATIONAL SUPPORT FOR COLLABORATIVE DECISION-MAKING

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FINAL REPORT

Submission Date: September 30st, 2011
Contract Number: N00014-08-1-0219

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1.4.1.1. Observations	Methods for collecting data
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1.4.1.4. Collaborative Analyses	Methods for analyzing Observations (collaborative level)
1.4.1.5. Collaborative Interpretations	Methods for interpreting Analyses (collaborative level)
1.4.2. Applications	Utilization of Assessments
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1.4.2.2. Adaptations	Methods for computational learning
1.4.2.3. Representations	Methods for visualizing and processing information
1.5. Protocols	Combinations of Methods
2. Framework 2	Separation of scenarios, experiments and use-cases
2.1. Components	Objects in the environment (tools, people, etc.)
2.2. Affordances	Object functions (capabilities, processes, etc.)
2.3. Setups	Object arrangements (locations, connections, etc.)
2.4. Procedures	Small events and activities
2.5. Scenarios, Experiments, Use-Cases	Combinations of Procedures

Note: This final report does not describe the EWall project in its entirety but focuses on work conducted during the current grant period. A publication on this effort is forthcoming. For additional detail on the EWall project please refer to previous reports and publications.

1. Abstract

This effort is aimed at exploring computational opportunities for utilizing theories of team-collaboration. We introduce a first Framework for monitoring, assessing and measuring team-collaborative processes. The Framework helps explain team-collaborative processes as combinations of multiple Methods that can be studied individually or in combination. We also introduce a second Framework for describing, analyzing and developing team-collaborative scenarios, experiments and use-cases. The second Framework is designed to evaluate and study Methods in particular situations. Furthermore, we demonstrate opportunities for translating Methods into computational agents that can analyze and support team collaboration and knowledge management. A hypothetical scenario is used to demonstrate and explain the use of Methods and the conceptualization of computational agents.

2. Objectives and Approach

The general objective of the EWall project is to conceptualize and prototype a computational environment for the support of individual and collaborative sense-making activities. The EWall environment is designed to engage people in the visual organization of information through the spatial arrangement and modification of information in an object-like format. Computational agents infer from the spatial and temporal arrangements and the collaborative use of information. The computational agents support the information exchange among collaborating users by enabling a non-interruptive interchange of contextual discoveries between humans and computers during sense-making activities. The EWall environment is intended to be used for conducting sense-making activities, for monitoring and investigating sense-making activities, and for developing and testing computational agents that can support sense-making activities.

The objective of the current grant was to adjust existing and innovate new concepts, functions, agents and taxonomies that will situate the EWall system within the domain of cognitive science. The goal was to computationally leverage theories of team-collaboration in ways that can support collaboration and knowledge management as well as to explore applications and processes for the transition of such technologies into operational environments. The outcomes from these efforts include a:

- Framework for assessing, measuring and leveraging team-collaborative processes
- Framework for developing and describing team-collaborative scenarios, experiments and use-cases
- Set of Methods for the observation, analysis and interpretation of team collaborative processes
- Set of Methods for the visualization and computational support of team collaborative processes
- Concept for a computational agent system that is based on team-collaborative theories.

3. Conceptual Frameworks

We developed two conceptual Frameworks (Figure 1) that constitute the foundation for our research efforts: Framework 1 is designed for investigating team-collaborative processes and the subsequent development of team-collaborative agents. Framework 2 is designed for investigating and explaining the use and potential deployment of team-collaborative agents in particular situations and environments.

Note: The two Frameworks are of general applicability and not depend on the previously conceived EWall software prototype. Our efforts are intended to inspire and support research into team-collaboration and to translate into a variety of computational solutions and applications.

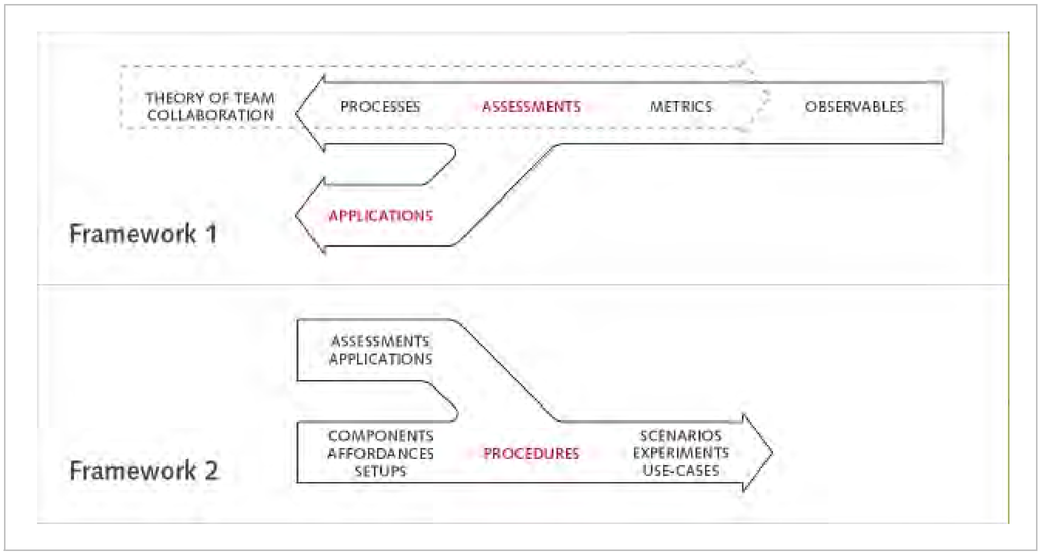

Figure 1

Conceptual Frameworks

Framework 1 helps explain team-collaborative processes.

Framework 2 helps break down scenarios, experiments and use-cases.

3.1. Framework 1

Our goal for Framework 1 was to explain team-collaborative processes as a combination of Methods that can be investigated individually, recombined into various different team-collaborative processes, and translated into computational agents.

The conventional and theoretical approach for investigating team-collaboration (Figure 1, Framework 1, Right-Pointing Arrow) is to start out with a theory of team collaboration, identify possible team-collaborative processes, and then find means to assess and measure these processes. Our more pragmatic, practical and data-driven approach (Figure 1, Framework 1, Left-Pointing Arrow) is to start out by investigating what can be observed (Observables) during collaboration and knowledge management activities, subsequently find means to measure (Metrics) and assess (Assessments) these Observables, and finally identify team-collaborative processes (Processes) that build on Metrics and Assessments. Optimally, the resulting operational definitions for team-collaborative processes end up to be similar for both the theoretical and practical approach.

The advantage of the theoretical approach is that definitions of team-collaborative processes can potentially be conceived in a short period of time while the development of operational definitions is likely to result in a more challenging and long-lasting effort. The reason for this is that the conception of theoretical definitions can happen independent of the prior investigation of supporting Assessments, Metrics and Observables. Thus, the primary concern with the theoretical approach is that it may result in the conception of a large number of possible team-collaborative processes that may or may not be compatible with any conceivable Assessments, Metrics and Observables.

Our efforts in regards to Framework 1 was not only to focus on identifying Assessments, Metrics and Observables for team-collaborative processes but also on investigating possible Applications (Figure 1, Framework 1, Left-Pointing Arrow). More specifically, we not only detect and assess team-collaborative processes but also explore options to use this knowledge in ways that can effectively support and benefit team-collaboration and knowledge management activities. For example, we might observe the conversation of three people and “assess” that only two of these people agree on a particular issue. A possible Application would be to communicate these findings or to actively help these people to get in agreement with one another.

Note: Because Framework 1 was conceived as a basis for developing computational applications we exclusively focused on investigating Assessments and Applications that can be automated, that are non-intrusive, and that can be executed in real-time.

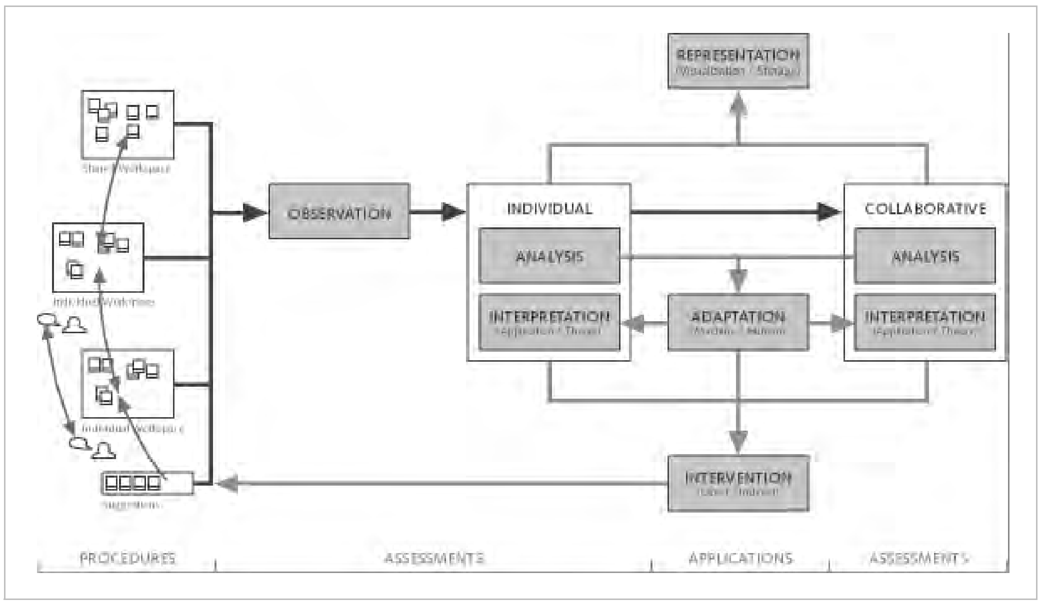

Figure 2

Framework 1 breaks down team-collaborative processes into various types of Assessment and Application Methods (gray shaded boxes).

Figure 2 illustrates the detailed breakdown of Framework 1. We distinguish between Procedures, Assessments and Applications. Procedures (see Framework 2) are specific events (e.g. team-collaborative events) that can be monitored. Different types of Assessments and Applications are represented by gray boxes. One particular Assessment or Application is referred to as a Method or, more specifically, an Assessment or Application Method. A Method has only one purpose or task, receives input from other Methods and provides output to other Methods. The arrows in Figure 2 display the primary flow of information between Methods. Methods can be understood as building-blocks for modeling team-collaborative constructs. In other words, team-collaborative constructs can be explained as a particular selection and combination of Methods. Thus, the number and quality of available Methods determines the number and quality of conceivable team-collaborative constructs. A more detailed explanation of individual Assessment and Application Methods is provided below.

Assessment Methods:

<u>Observation Methods</u> monitor and collect information about the activities of people and computational systems. For example, Observation Methods may keep track of how EWall users spatially arrange

information (Cards), what information people exchange, or which people communicate with each other. Observation Methods produce the “Data” needed by other types of Methods. The combined output of multiple Observation Methods may also translate into an activity log.

Individual Analysis Methods convert the data generated by Observation Methods into a more comprehensible format that serves as a basis for subsequent Interpretations. Typical techniques for analyzing data include multi-dimensional scaling and cluster analysis. Individual Analysis Methods focus exclusively on the analysis of data that reflects the activities of individual people and computational systems.

Individual Interpretation Methods review the output from Individual Analysis Methods and speculate about the presence, evolution and state of particular team-collaborative constructs. For example, Individual Interpretation Methods might investigate the Mental Model Development or current Expertise (knowledge base) of an individual person or computational system.

Collaborative Analysis Methods operate like Individual Analysis Methods yet focus exclusively on analyzing the collaborative activities of multiple people and computational systems. Collaborative Analysis Methods primarily obtain input from Observation Methods, Individual Analysis Methods and Individual Interpretations Methods.

Collaborative Interpretation Methods operate the same as Individual Interpretation Methods yet conclude from the analyses produced by Collaborative Analysis Methods. A typical Collaborative Analysis Method might investigate Team Mental Model Development or Shared Expertise.

Note: We refer to the output from Observation Methods as Data, the output from Analysis Methods as Information, and the output from Interpretation Methods as Knowledge.

Application Methods:

Intervention Methods are designed to actively influence the activities of individual people and computational systems in ways that can enhance collaboration and knowledge management. Individual Intervention Methods usually build on particular team-collaborative concepts such as Team Shared Understanding or Knowledge Sharing. For example, the goal of one Intervention Method might be to increase Team Knowledge Sharing by informing individuals about documents that are used by most of their team mates.

Adaptation Methods are designed to help computational systems learn from past experience and adapt to new and unique situations. Adaptation Methods monitor and evaluate the effectiveness of other Methods and subsequently adjust the settings and configurations of these Methods in ways that can increase system performance. For example, an Adaptation Method might recognize an increase in Team Shared Understanding that can be traced back to the repeated application of a particular Intervention Method. Subsequently, the Adaptation Method might suggest that this Intervention Method is applied more frequently.

Representation Methods consolidate and visualize the operations and conclusions of other Methods. For example, a Representation Method might visualize emerging relationships between people based on who communicates with whom, or collect and organize the documents exchanged among team members in a shared database. Representation Methods are designed for team managers and

researchers to monitor and analyze team collaboration, for developers to adjust system operations, and for computational systems to converge and structure the knowledge accumulated during team-collaborative activities.

3.2. Framework 2

Our goal for Framework 2 was to break down Scenarios, Experiments and Use-Cases into smaller elements that can be investigated individually and that can be used to assemble new Scenarios, Experiments and Use-Cases.

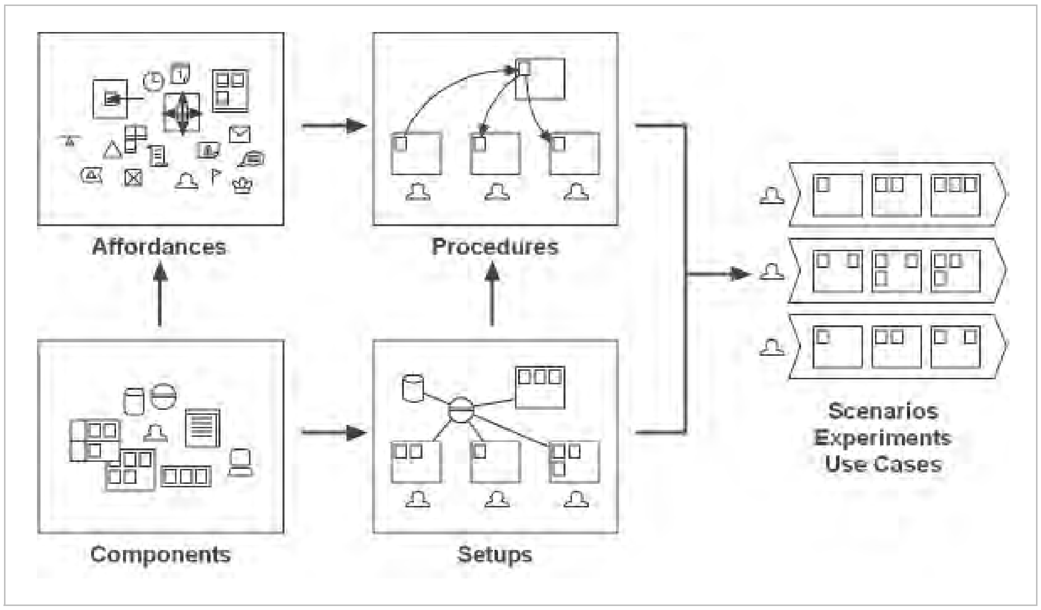

Figure 3

Framework 2 breaks down Scenarios, Experiments and Use-Cases into smaller elements.

Figure 3 illustrates a detailed breakdown of Framework 2. Framework 2 is primarily intended to support the conceptualization of Methods (see Framework 1). Methods are best investigated with respect to specific events and activities rather than entire Scenarios, Experiments and Use-Cases. We refer to these specific events and activities as Procedures. Procedures are composed of Components, Affordances and Setups. Combinations of multiple Procedures translate into Scenarios, Experiments and Use-Cases. A more detailed description of the individual elements in Framework 2 is provided below:

<u>Components</u> are objects in the environment such as tools and people that are needed for the execution of a particular activity. For example, a team collaborative activity might involve three people that use email as a means to communicate. Both the people and the email software are considered Components.

<u>Affordances</u> describe the functions, capabilities and operations of Components. For example, a particular person might offer expertise in neuroscience or a computer application might allow for the transfer of messages and documents between people.

<u>Setups</u> describe the organization (physical locations and connections) of objects at specific points in time. For example, person A and B might be located in space 1 and 2 respectively, and communicate with each other through email. Setups usually don’t change during research experiments but have a tendency to transform frequently in real-life situations.

Procedures refer to short sequence of events and activities. A typical example of a Procedure is the transmission of an email from one person to another. (The Observation Methods in Framework 1 are designed to monitor for the occurrence of specific Procedures.)

Scenarios, Experiments and Use-Cases are sequences of Procedures that are supposed to satisfy particular goals or purposes. For example, the exchange of documents between people might involve several Procedures such as requesting documents, receiving documents, and confirming the receipt of documents. Procedures may be applied repeatedly, and the selection and order of Procedures may dynamically change depending on circumstances.

Note: An alternate and less abstract Scenario for explaining Framework 2 is the process of mounting a frame onto a wall. The Components include a person, a wall, a frame, a hammer and a nail. The Affordances for the person are to move the frame, the hammer and the nail; the Affordances for the hammer are to strike an object; and the Affordances for the nail are to penetrate a wall and act as a hook. The Setup for this process places the person in front of the wall with the hammer in one hand and the nail in the other hand. The Scenario involves multiple Procedures one of which is for a person to strike a nail with a hammer and another one is for a person to attach a frame to a nail.

4. Demonstration

In this chapter we explain Framework 1 and 2 within the context of a short hypothetical scenario (based on the Non-Combatant Evacuation Operation scenario by Warner N. et al.) that involves several team-collaborative activities and that utilizes the EWall environment as a means for users to collect, organize and exchange information. We initially describe the setting for this scenario with Framework 2 and subsequently explain the application and operation of a few example Methods with Framework 1.

Note: Framework 1 and 2 are designed to be EWall independent. We demonstrate our concepts within the context of the EWall environment because the EWall interfaces allow for a more illustrative visualization of user activities and computational operations, and because our effort were primarily intended to advance EWall technologies.

4.1. Setting

Components: The setting involves three participants (User 1-3) as well as three EWall Workspace Views (Workspace 1-3) on individual computers.

Affordances: The three participants have different areas of expertise. The first participant (User 1) is a Land Vehicle Specialist (LVS). The second participant (User 2) is a Personnel Specialist (PS). The third participant (User 3) is an Air Vehicle Specialist (AVS). The EWall Workspace View (Workspace) allows users to collect and spatially arrange task-relevant information retrieved from web sites and file systems. Every piece of information on the Workspace is represented as a visual object (Card). Every Card displays a picture, a heading and a category color. Cards are hyperlinked to the original source of information. Cards can be exchanged between the Workspaces of different users.

Setups: Every user controls one Workspace. The users are spatially located next to each other, can verbally communicate with each other, and can see the contents of each others' Workspaces.

Procedures: The users can populate their Workspaces with task-relevant information, arrange Cards in ways that helps comprehend the information, categorize Cards with different colors, copy Cards from the Workspaces of other Users, and send Cards to other users.

Scenario: The Users collaboratively investigate a hostage situation and plan a rescue operation. The users initially work independently to investigate the situation based on their unique expertise and view points before engaging into a more collaborative effort that is supposed to conclude with a concrete plan for the rescue operation.

4.2. Events

Figure 4 illustrates the evolution of the Workspaces during the execution of the scenario. The rows display, from top to bottom, the Workspaces of different users (Users 1-3) and the columns, from left to right, the Workspaces at different points in time (Time 1-3). A brief summary of scenario events is outlined below:

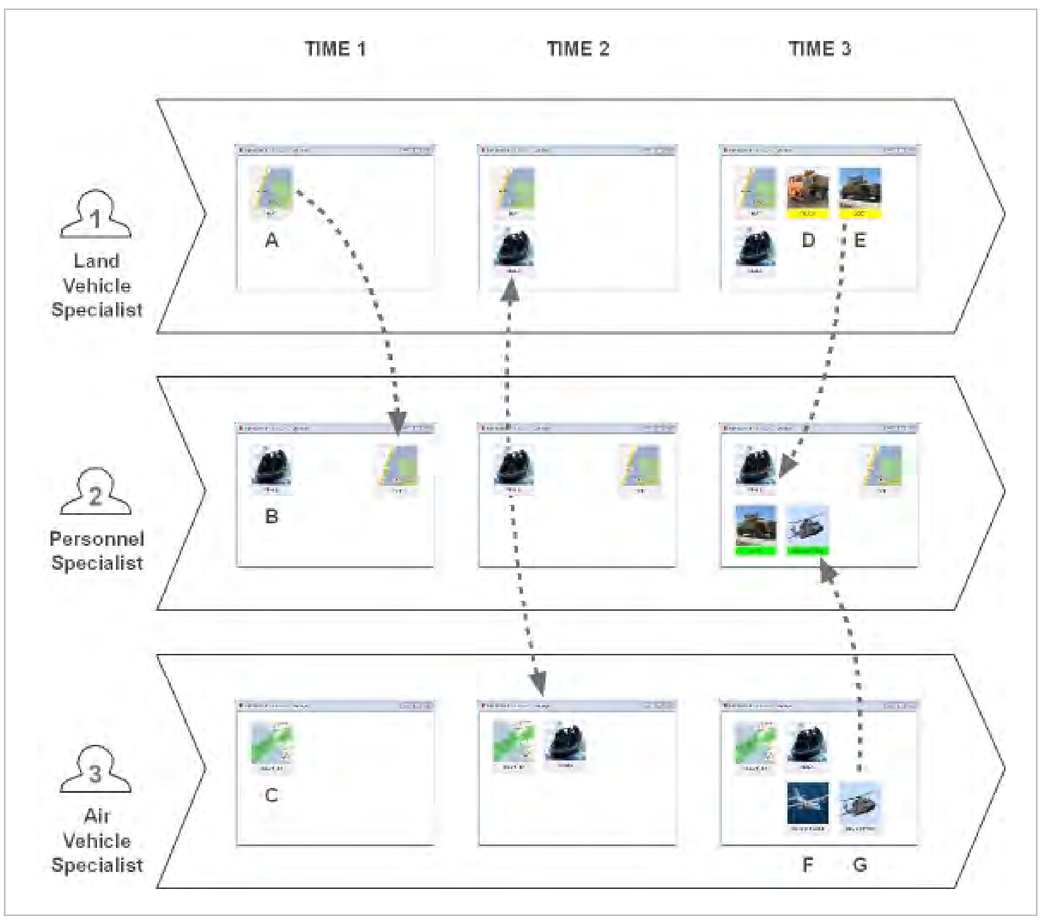

Figure 4

Scenario Events

Workspaces of different users (rows) at different points in time (columns).

Time 1: During the first stage of the scenario the experts individually collect task-relevant information relevant to their unique areas of expertise.

- The LVS is concerned with terrain related issues and adds a Card (A) to his Workspace that references geographic information about the target area.
- The PS reviews available personnel resources, considers a currently available SEALS team as one possible option for the rescue mission, and adds a Card (B) to his Workspace that references detailed information about the SEALS team. Furthermore, the PS notices the Card (A) with geographic information on the LVS's Workspace, considers this information useful to his own investigations, and copies the Card (A) to his own Workspace.
- The AVS is focused on investigating the meteorological condition in the target area and adds a Card (C) to his Workspace that links to a web site with relevant weather data.

Time 2: During the second stage of the scenario the experts start to communicate with each other.

- The PS asks the LVS and the AVS to consider his choice of personnel and to propose possible transport options to and from the target area. The PS distributes a copy of the Card (B) with information about the SEALS team to the LVS and AVS for future reference.

Time 3: During the third stage of the scenario the experts start to evaluate and discuss available transport options for the rescue mission.

- The LVS considers a Truck and a Jeep as potential transport options for entering the target area and creates two Cards (D, E) that reference detailed information about these two vehicles. The LVS uses yellow category colors to highlight Cards (D, E) that represent transportation options.
- The AVS considers a Cargo Plane and a Helicopter as potential options for exiting the target area. The AVS creates two Cards (F, G) that reference detailed information about these two transport options.
- Both, the LVS and the AVS verbally communicate their options with the PS. The PS believes that the Jeep and Helicopter present his choice of team with the best possible transportation options and copies the two respective Cards (E, G) to his Workspace View. The PS uses green category colors to more easily distinguish transportation related Cards (E, G) from other Cards.

4.3. Methods and Protocols

This chapter reviews the scenario events based on Framework 1. Figure 5 illustrates the selection and sequential application of Methods. The lower portion of Figure 5 shows eight lists of Methods (A-H). Every list contains different types of Methods. The first five lists contain Assessment Methods (A-E) and the remaining three lists contain Application Methods (F-H). The Methods circled in red represent the Methods we choose to investigate our scenario with respect to one particular team-collaborative construct (Team Mental Model Development). The red lines connecting the Methods display dependencies. For each pair of connected Methods, the Method on the right builds on the output produced by the Method on the left.

A combination of Methods is referred to as a Protocol (Figure 5, Top, White arrows). Assessment Protocols are composed of Assessment Methods, and Application Protocols are composed of Application Methods. Different Protocols investigate different team-collaborative constructs or investigate the same team-collaborative construct in different ways. Because the effectiveness of particular Protocols differs depending on the situation, the investigation and evaluation of a particular team-collaborative construct often requires the simultaneous application of multiple Protocols (Figure 5, Top, Gray arrows). For example, one Protocol may infer Team Mental Model Development based on the information exchanged between team members and another Protocol based on the shared use of information. If team members do not exchange information then only the second Protocol can be effective. If team members exchange information and access shared information then both Protocols can be utilized and the conclusions of both Protocols compared. Hence, the primary purpose for the conceptualization and simultaneous application of multiple Protocols is to account for different and potentially new and unique situations as well as to increase the quality of the examination by investigating each situation from multiple different perspectives.

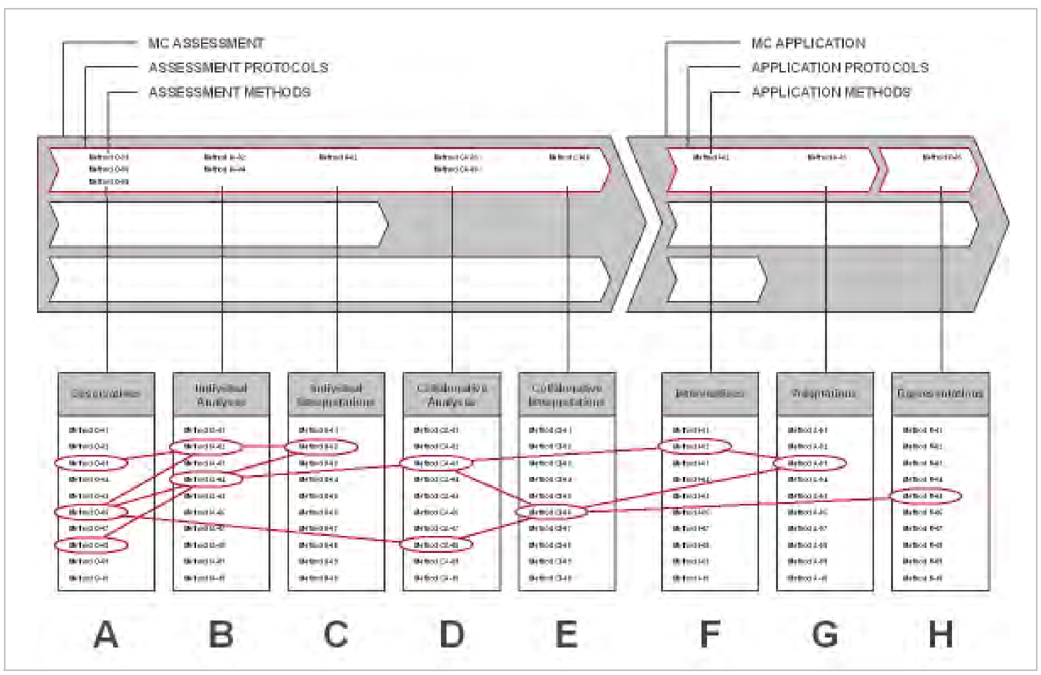

Figure 5

Selection and application of Methods.

Applications consist of multiple Protocols.

Protocols consist of multiple Methods.

Note: Our short scenario allows for the simultaneous investigations of various different team-collaborative constructs and Protocols. For simplicity reasons, our demonstration only includes one team-collaborative construct (Team Mental Model Development) and only one Protocol.

Note: Figure 5 displays ten different Methods in each list (A-H). This is for illustration purposes only. Every list may contain any number of Methods and our efforts have no yet resulted in ten Methods for each category.

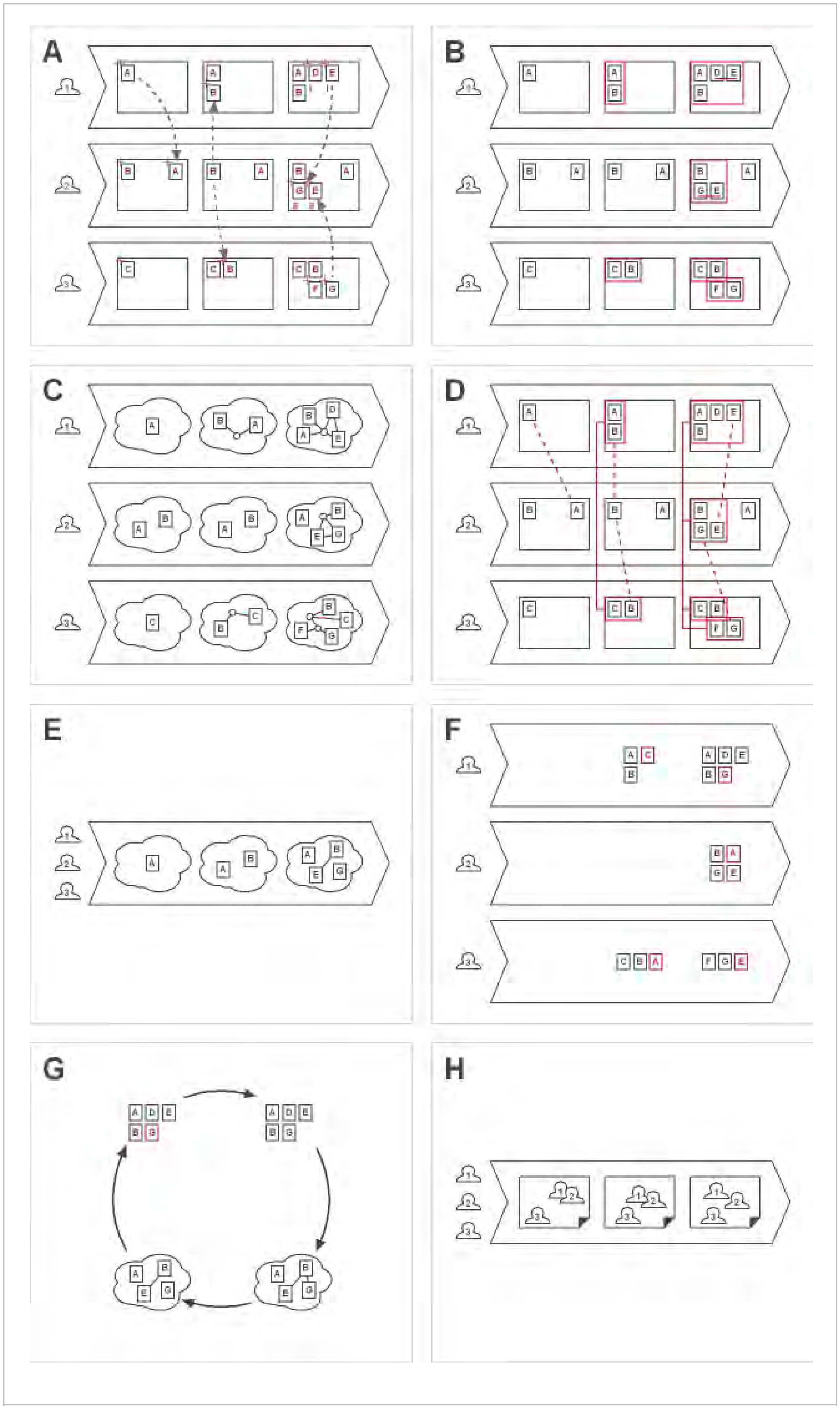

Figure 6

Operations of Methods.

A. Observations

B. Individual Analyses

C. Individual Interpretations

D. Collaborative Analyses

E. Collaborative Interpretations

F. Interventions

G. Adaptations

H. Representations

A. Observations: For our investigation of Mental Model Development we choose three different Observation Methods (Figure 6A). The first Method monitors the appearance of new Cards on User Workspaces and maintains a record of which Cards are used by which User at what time (e.g. User 2, Time 2, Cards A and B). The second Method keeps a record about the spatial locations of Cards (e.g. User 3, Time 3, Card C = Top Left). The third Method associates Cards and categories (e.g. User 1, Time 3, Card D = Yellow).

B. Individual Analyses: Two Individual Analysis Methods (Figure 6B) estimate possible relationships between Cards. The first Method creates relationships based on the spatial grouping of Cards (e.g. User 3, Time 3, Cards B and C) (Figure 6B, Red Bounding Boxes) and the second Method based on Card categories (e.g. User 1, Time 3, Cards D and E) (Figure 6B, Red Lines). The two Individual Analysis Methods depend on the output produced by the three Observation Methods. For example, the spatial location of Cards is required to infer Card groupings.

C. Individual Interpretations: We demonstrate one Individual Interpretation Method (Figure 6C) that infers from the findings produced by the Individual Analysis Methods (B). This particular Method speculates about Individual Mental Model Development by estimating possible relationships between Cards that Users may have mentally conceived but not made explicit. For example, User 3 created two groups of Cards (Time 3). The Individual Interpretation Method assumes that User 3 recognized some sort of relationship between the Cards in each group. Because both Card groups are located in close spatial proximity, the Method additionally considers a relationship between the two groups. The Method also constructs possible relationships between Cards based on Card categories. For example, User 1 assigned the same category (Yellow) to two Cards. The Method subsequently established a relationship between the two Cards assuming that User 1 detected one or more shard properties between the two Cards. The visualization in Figure 6C displays the relationships derived from the spatial grouping of Cards and the categorization of Cards. Cards are represented as Boxes, Groups as Circles, and possible relationships between Cards as Lines. The emerging networks of Cards are assumed to align themselves with the evolving Mental Models of individual Users.

D. Collaborative Analyses: Our scenario includes two Collaborative Analysis Methods (Figure 6D) that infer from the simultaneous activities of multiple Users. The first Method investigates the shared use of Cards. For example, both Users 1 and 2 maintain a copy of Card A on their individual Workspaces during Time 1, and all three Users share a copy of Card B during Time 2. The second Method investigates the generation of similar Card groupings between different Users. For example, the Card groups of Users 1 and 2 during Time 3 are somewhat similar because both Card groups include Cards B and E. The two Collaborative Analysis Methods depend on the output produced by one Observation Method (A) and one Individual Analysis Method (B). The Observation Method provides information about which Users are using which Cards and the Individual Analysis Method informs about Card groupings.

E. Collaborative Interpretations: We introduce one Collaborative Interpretation Method (Figure 6E) that infers from the findings produced by the Collaborative Analysis Methods (D). This particular Method speculates about Team Mental Model Development and visualizes the assumed Team Mental Model as a network of Cards and relations between Cards. The Method exclusively considers Cards and relations

that are shared among the majority of Users. For example, during Time 1, Card A is displayed because it is shared among two out of three Users. Furthermore, during Time 3, the relation between Card B and E is displayed because the two Cards were grouped similarly by two Users.

F. Interventions: We explain one Intervention Method (Figure 6F) that receives input from one Collaborative Analysis Method (D). The goal of this Intervention Method is to foster similar Card groupings among Users by presenting individual Users with suggestions about the use of additional Cards and the spatial positioning of Cards. The assumption is that the emergence of similar Card groupings among different Users is indicative for Team Mental Model Development, and that encouraging similar Card groupings may accelerate Team Mental Model Development. In our scenario, the Intervention Method detects similarities between the Card groupings of User 1 and 2 because both groupings contain Cards B and E (Figure 6D, Time 3). Subsequently, the Intervention Method proposes that User 1 adds Card G to his group of four Cards, and that User 2 adds Card A to his group of three Cards (Figure 6F, Time 3). If one or both Users adapt the proposed Card additions then the Users' Card groups will become more alike and positively impact the development of the Team Mental Model (E).

G: Adaptations: Our demonstration includes one Adaptation Method (Figure 6G) that interacts with the previously explained Collaborative Interpretation Method (E) and Intervention Method (F). The goal of this particular Adaptation Method is to ensure that successful Intervention Methods are applied more frequently. For example, the success of the Intervention Method (F) is defined by Team Mental Model Development and measured by an increase of shared Cards and relations in Figure 6E. The Adaptation Method investigates whether there is an increase in Team Mental Model Development that can be contributed to a particular Intervention Method. If Users adapt suggestions by the Intervention Method and if subsequently the Team Mental Model increases (indirect positive feedback) then our Adaptation Method will ensure that the Intervention Method will be used more frequently in the future. (Note: To prevent the permanent domination of particular Methods, Adaptation Methods only provide temporary support to successful Methods and occasionally promote less successful Methods as well.) (Note: Our scenario is too short for an Adaptation Method to effectively evaluate the impact of other Methods.)

H. Representations: We demonstrate one Representation Method (Figure 6H) that informs about the current state of the Team Mental Model. The Method visualizes similarities between the Users' Individual Mental Models through the proximal arrangement of User icons. For example, during Time 1, the icons representing Users 1 and 2 are visualized in close spatial proximity. This suggests potential similarities between the Individual Mental Models of Users 1 and 2. The icon representing User 3 is located in a distance which is indicative for a significant derivation of User 3's Mental Model. The Representation Method monitors Team Mental Model Development over time. For example, the changes to the visualization between Times 1 and 3 suggest an increasingly balanced but weakening Team Mental Model among the three Users. (Note: An alternative Representation Method for investigating Team Mental Model Development was used in Figure 6C and 6E.)

5. Conclusion and Future Work

We discussed two conceptual Frameworks for the investigation of team-collaboration and for the development of computational systems that can monitor and support team-collaboration. The Frameworks introduce a bottom-up approach for breaking-down team-collaborative constructs into smaller, combinable and more easily analyzable components. The Frameworks can help researchers to deal with some of the complexities that have traditionally hindered the effective design, description and evaluation of team-collaborative constructs.

A computational implementation based on Framework 1 is being realized by one of our collaborators. Subsequent efforts will focus on conceptualizing additional Methods and Protocols as well as on customizing and testing Methods and Protocols for particular applications and users.

6. EWall Publications

Submitted:

2011 Keel P, Cooke N, Sither M. Improving Cognitive Interaction through Computational Collaboration Agents. TIES (Theoretical Issues in Ergonomics Science).

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